

BIOLOGICALLY CONTROLLED MINERALS AS POTENTIAL INDICATORS OF LIFE

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Minerals can be produced and deposited either by abiotic or biologic means. Regardless of their origin, mineral crystals reflect the environmental conditions (e.g., temperature, pressure, chemical composition, and redox potential) present during crystal formation. Biologically-produced mineral crystals are grown or reworked under the control of their host organism and reflect an environment different from the abiotic environment. For example, we have gathered sufficient evidence demonstrating that most biologically controlled minerals have attributes, such as morphologies and isotopic ratios, which differ from an abiotically produced mineral of the same chemical composition. In addition, minerals of either biologic or abiotic origin have great longevities. For these reasons, biologically produced minerals have been proposed as biomarkers. Biomarkers are key morphological, chemical, and isotopic signatures of living systems that can be used to determine if life processes have occurred.

To date, more than 60 different minerals have been identified as being produced or reworked by an assortment of organisms. Several of these minerals and the organisms that produce them have been well studied, such as magnetite produced by bacteria and aragonite produced by mollusks. Although some of the minerals produced by organisms, such as silica produced by diatoms, are abundant, very widely distributed, and have played an important role in the geologic record, much work still remains to be done.

The technique of using biologically-produced minerals as biomarkers has great potential and must be tested. The key to the use of minerals as biomarkers is the ability to distinguish between abiotically and biologically produced minerals. To accomplish this, universal traits unique to biologically controlled minerals must be identified. We have begun studies of biologically controlled minerals produced by the protist Paramecium tetraurelia since techniques have already been developed to culture them and isolate their crystalline material, and methods are already in place to analyze this material. Two direct crystalline phases have been identified. One phase, whose chemical composition is high in Mg, was identified as struvite. The second phase, whose chemical composition is high in Ca, has not been previously found occurring naturally and may be considered a newly discovered material. Analyses are currently underway to determine the characteristics of these minerals in order to compare them with characteristics of minerals formed abiotically, but with the same chemical composition.